# Local evaluation techniques in bus line planning

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Public transport is essential to cope with the ever increasing demand for mobility. Hence, it is important to utilize all available resources as efficiently as possible. For a public transport system, this efficiency depends strongly on the decisions made during the planning process -[1]-. The planning process usually consists of a few different phases. One of these steps is line planning, where a public transport company decides where its vehicles will drive, which stops will be served and in which order. A main challenge of the bus line planning problem is finding a good solution for (very) large networks -[2, 3]-.

The problem is that the evaluation of a line plan is computationally quite costly. In an evaluation, the total travel time of all the passengers is calculated. To make such a calculation, the route each passenger takes has to be known. In line planning, this is nearly always done by finding the shortest path for all origin-destination pairs. Deciding which routes are used to get from each possible origin to each possible destination is the most time consuming part of the evaluation-[4]-.

Local evaluation techniques can be used to decrease the computational burden of each evaluation. The computational burden scales more than linearly with the size of the network -[3]-, limiting the calculations to the part of the network where a change has happened thus results in a significant decrease in computation time. Apart from being able to find a result for larger networks, this also allows the use of more complex and realistic techniques or the integration of some of the other planning steps into the line planning process.

This paper implements local evaluation techniques based on two core principles. The first idea is that the impact of a change decreases the further you move away from this change, and the second one is that in a good line plan passengers only make a low number of transfers to get to their destination. In stead of always evaluation the entire transit network, a smaller network is cut from the original using the two core principles. It is then assumed that all routes that enter and/or leave this cut, will still do so on the same place after the change. This means that the current route travelled by each passenger has to be saved. With this information, the demand of the cut can be constructed from the demand for the complete network. Note that routes that previously did not use any of the lines included in the cut are assumed not to change, nor will any routes change their place of entry nor exit in the cut-out network.

To test this framework, an iterated local search algorithm is developed to solve the line planning problem. This algorithm constructs a line plan from scratch and then improves the current solution until a local optimum is reached. Then, a part of the solution is destroyed and a new search for a local optimum begins. This process continues until the stop criterion is reached.

While the local evaluation techniques are applied to an iterated local search, the two core concepts can be applied to many other algorithms and could be useful for all research in line planning or for other similar public transport optimization problems.

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